SEMANTICS AND KNOWLEDGE CAPITALIZATION IN ONLINE COMMUNITIES OF PRACTICE OF E-LEARNING

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Abstract: Knowledge management in Communities of Practice of E-learning (CoPEs) is challenged by several issues: the complexity of knowledge, considered as interdisciplinary (psycho-cognitive, pedagogic, software-oriented, and hardware-oriented), the difficulty to access and reuse that knowledge, and the complexity of the knowledge capitalization process. Most of the knowledge exchanged is mainly tacit, based on direct communication between members, and therefore needs to be elicited and represented in a formal way to be capitalized. Explicit knowledge is generally shared and accessible through the CoPE's repositories. However, it is not always well elicited and organized. In this paper, we propose an ontology-based framework for capitalizing knowledge for reuse in CoPEs. We show through an example of use how semantics can contribute to the management of the tacit knowledge that the community members own and therefore to the improvement of the learning process in CoPEs.

1 INTRODUCTION

Recent researches show that Communities of Practice (CoPs) play an important role in the management of the tacit knowledge that the community members own (Wenger, 2004; Kimble and Hildreth, 2004). A CoP has become associated with knowledge management, in particular as a way of transferring tacit knowledge. CoPs have several characteristics that distinguish them from formal organizations. In fact, according to Wenger (2004) such communities are groups of people who share a concern, a set of problems, or a passion about a topic (the *domain* of the community), deepen their expertise and practical knowledge (the *practice* of the community), and interact on an ongoing basis (the *community* itself).

Communities of Practice of E-learning (CoPEs) (Chikh et al., 2007; 2008) are considered as a virtual framework for exchanging and sharing techno-pedagogic knowledge and know-how between actors of e-learning (e.g. teachers, tutors, administrators, etc.). Recently, we can see the emergence of CoPEs. For example: the CoPe-L (CoP of e-learning at Luxembourg), has been created in the framework of Palette project (2006), and whose objective is to share practices and promote e-learning activities; CoP of tutors Learn-Nett (Learning Network for Teachers and Trainers - http://learn-nett.org), is focused on a shared course and aims at preparing future teachers or trainers for educative uses of Information and Communication Technologies.

By using advanced technology, online CoPEs have the potential to bring members together virtually, to learn from each other, collaborate and share expertise and techno-pedagogic practices.

We address in this paper the problem of capitalization of knowledge, both tacit and explicit, in a way that facilitates its access and reuse. Due to the informal character of learning within a CoPE, most of the knowledge is mainly tacit, based on direct communication between members, and then needs to be elicited and represented in a formal way to be capitalized. Moreover, explicit knowledge is generally shared and accessible through the CoPE's repositories. But, it is not always well elicited and organized and then needs to be more explicit, so as to improve access, sharing and reuse of this

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knowledge.

We propose in this paper an ontology-based framework for capitalizing knowledge for reuse in CoPEs. Ontologies, generally defined as a representation of a shared conceptualization of a particular domain (Gruber, 1993), is a major component of the semantic web. The role of ontologies is to assist persons and organizations by providing a common vocabulary, to achieve interoperability between different environments, and to improve consistency information retrieval. In our context, the ontology-framework will provide a common backbone for capitalization of knowledge, both tacit and explicit, allow to annotate the CoPE's knowledge resources in order to facilitate their retrieval and reuse; provide a shared understanding between the different actors of e-learning; and facilitate exchanges between the CoPE environment and the Learning Management Systems (LMS).

2 RESEARCH PROBLEM

In a CoPE, members can openly discuss and brainstorm about their problems and experiences, related to the development and use of online learning systems. The interactions are conducive to developing new knowledge, stimulating innovation, or sharing existing tacit and/or explicit knowledge between e-learning actors.

On one hand, those actors have tacit techno-pedagogic knowledge which they learnt from their experience in different e-learning projects. However, that knowledge is not always capitalized in the memory. Sharing such knowledge is considered as a big challenge: it must be efficiently and effectively represented in order to be further exploited.

On the other hand, explicit knowledge, which includes learning resources, is generally shared and accessible through the CoPE's repositories. However, it is not well elicited and organized (e.g. lack of information related to feedback use, validity and assessment).

In the context of a CoPE, we distinguish two types of knowledge reuse: the explicit knowledge reuse (e.g. reuse of knowledge resources) and the tacit knowledge reuse (e.g. reuse of some hints provided by another member having more experience). Our objective consists to make the reuse explicit and to well organize it, so as to make it more efficient.

Consequently, our main research question is: "How to represent knowledge, tacit and explicit, within the framework of a CoPE, so as to facilitate its access and reuse?"

In this paper we try to answer the following sub-questions:

- How can we help members to formalize and capitalize tacit knowledge?
- How do we organize the CoPE memory in order to enhance the reuse of its content by members?
- How do we enrich learning resources with metadata in order to improve their reuse?

3 RELATED WORK

Recently, a lot of research works was interested to knowledge management and capitalization within a CoP, to name but a few: the Palette project (2006), where several knowledge management services were proposed to support CoPs. These services rely on a semantic web-based approach using ontologies (Tifous et al., 2007), for annotating knowledge in order to facilitate their transfer and sharing. Other works are based on the concept of organizational learning memory to capitalize tacit knowledge (Leblanc and Abel, 2008).

In the context of CoPEs, Quénu-Joiron and Condamines (2009) developed a web community platform dedicated to knowledge capitalization and on-line know-how transfer between experienced teachers and beginners. While Quénu-Joiron and Leclet (2010), implemented a CoP dedicated to project based pedagogy tutors using a case-based reasoning approach.

4 KNOWLEDGE CAPITALIZATION IN COPES

4.1 Knowledge Capitalization Process

The process of knowledge capitalization can be seen as a cycle with several steps. Grundstein (1992) summarizes this process in four steps: detection, preservation, exploitation, and actualization. In (Oladejo et al., 2010) the authors propose the "Dynamic Capitalization" approach (see figure 1). There are five major phases in this approach and each phase is dynamic with respect to evaluation and validation of knowledge resources by actors. Knowledge can be elicited using the process of declaration and annotation. Knowledge resources are represented with the aid of a conceptual knowledge model. The acquired knowledge resource is stored

with temporal attributes, in a knowledge repository (i.e. for dynamic and non-volatile capitalization). The storage facilitates the reuse of knowledge through exploitation process. Acquired and stored knowledge resources can be exploited for reuse and sharing.

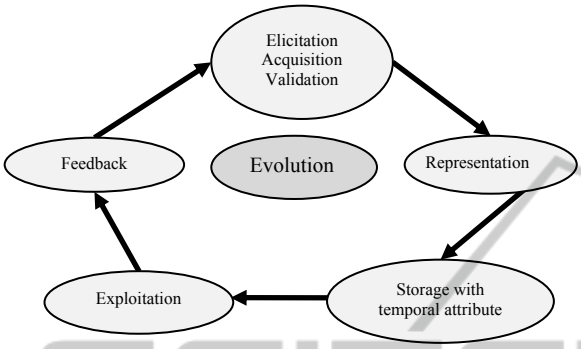

Figure 1: Dynamic capitalization approach, from (Oladejo et al., 2010).

The dynamic capitalization approach seems to be well adapted for our context of study, as it proposes a structure for knowledge reuse and encourages and favours the collaboration between actors.

4.2 Knowledge Capitalization Process in CoPEs

The capitalization process in a CoPE is considered as the result of continuous update from knowledge reuse and capitalization of lessons learnt by the community members. We discuss below the different steps of the dynamic capitalization approach applied to the context of a CoPE:

- Elicitation, Acquisition, Validation: knowledge is elicited from members through discussion using the annotation process (e.g. analysis comments). This supports the understanding and validation of knowledge among them.
- Representation: knowledge resources are represented using ontologies, knowledge models, etc.
- Storage: an organizational learning memory is used to store all the CoPE's knowledge resources.
- Exploitation: refers to the reuse of knowledge resources from the memory. For example, in the case of problem-solving, knowledge exploitation involves mining and visualization of knowledge for new cases of problems.
- Feedback exploitation strategy: members can be guided to externalize the knowledge derived from the reuse of knowledge resources in form of feedback.

5 THE ONTOLOGY-BASED FRAMEWORK

We present in this section, an ontology-based framework for knowledge reuse in CoPEs.

5.1 OntoCoPE – An Ontology for CoPEs

A general conceptual model for a CoPE, called OntoCoPE ontology, is based on the O'CoP ontology conceptual model for CoPs (Tifous et al., 2007) defined in the Palette project (2006) and on partial conceptual models for CoPEs proposed in (Berkani and Chikh, 2009).

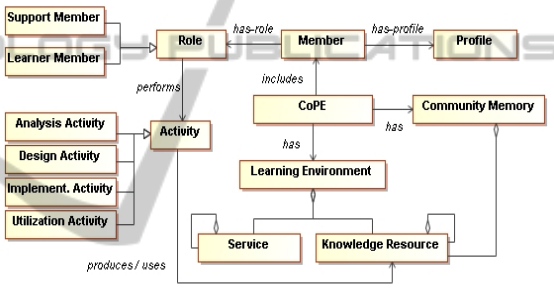

Figure 2: Main concepts of CoPEs.

5.2 Ontology-based Framework for CoPE Memory

The organizational memory refers to the place where the organization's information and knowledge resources are found. The use of ontologies helps the organization to become a "semantic learning organization". MEMORAe project (Organizational Memory Applied to the e-learning) illustrated the importance of using ontologies to represent an organizational learning memory in the context of an e-learning training (Abel et al., 2004) and for a community of learners (Leblanc and Abel, 2008).

To implement the CoPE memory, we propose an ontology-based framework in order to define a common vocabulary and to annotate the knowledge resources, and we provide a means of storage and indexing of knowledge resources. We propose to structure the memory into three layers, as shown in figure 3.

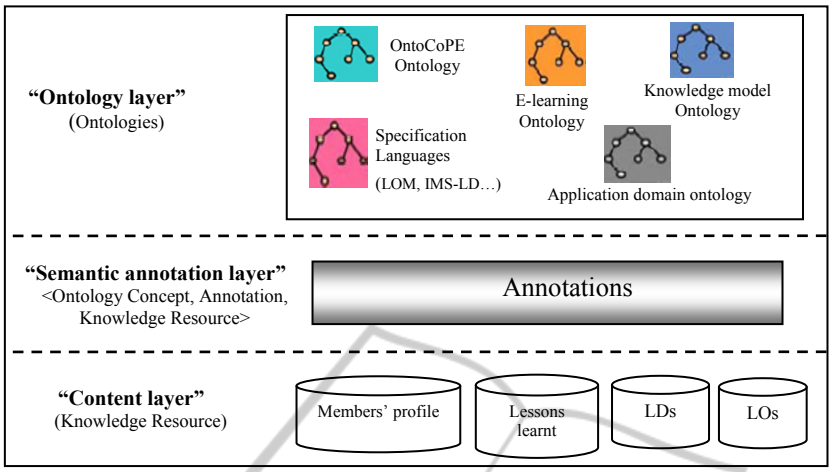

Figure 3: Ontology-based Framework for CoPE memory.

The CoPE memory is seen as a "semantic learning organization", described using an ontology-based framework structured into three layers as shown in figure 3. The framework provides a common vocabulary between the CoPE's members, a semantic support to annotate the CoPE's knowledge resources in order to facilitate their retrieval and reuse, and a means of storage and indexing the different data. We describe in the following the three layers:

5.2.1 The Ontology Layer

The ontology layer is based on several ontologies:

- OntoCoPE, an ontology for CoPEs (Berkani and Chikh, 2009), describes the main concepts of a CoPE: "Community", "Actor", "Role", "Profile", "Activity", "Process", "Resource", "Service and Tool", "knowledge", "Competency".
- An e-learning ontology, describing the concepts related to the domain of e-learning. This ontology will facilitate exchanges and transfer of knowledge between the CoPE environment and LMS.
- A knowledge model ontology, describes the different kinds of knowledge models such as lessons learnt and which can be developed for example using patterns and case-based reasoning.
- An application domain ontology, concerns a specific course (e.g. mathematics, software engineering, etc.).
- A specification languages, such as Learning Object Metadata (LOM, 2002) for describing learning objects, IMS Learning Design specification (IMS-LD, 2003) for describing learning designs, etc.

5.2.2 The Semantic Annotation Layer

Semantic annotations are generated automatically and assign knowledge resources of the content layer to concepts of ontologies included in the ontology layer. Information is represented as a triplet <Ontology concept, Annotation, Knowledge resource>.

5.2.3 The Content Layer

The content layer includes several repositories to store the different data:

- Members' profile: includes some attributes such as: experience; cognitive characteristics; communication skills; learning competences; learning objectives.
- Lessons learnt: correspond to positive or negative lessons learnt, related respectively to best or bad practices regarding the different stages of the development lifecycle (analysis, design, implementation and utilization) of an e-learning product.
- Learning Objects (LOs): are described using the standard LOM (2002). A semantic description of a LO using ontologies is proposed in (Jovanović et al., 2007). In the next sub-sections we present a model of LO in the context of CoPEs, in order to depict the specificities of a CoPE.
- Learning Designs: also called learning scenarios, are represented using the standard IMS-LD (2003) by identifying the necessary

learning activities and assigning LOs to those activities in order to achieve the specified learning objective.

5.3 Annotation Model

We use the annotations in the CoPE for the capitalisation of tacit knowledge. Annotations aim to evaluate and improve the understanding about knowledge resources, artefacts, processes, etc.

The model of the annotation is created on the basis of some previous works on annotations: DAML Ontology Library (2000) and (Fogli et al, 2005). We consider that an annotation may annotate one or more knowledge resources, a part of a knowledge resource or another annotation. An annotation may be related to several other annotations.

We have defined three kinds of annotations: (1) *the analysis annotation*, where members can write some comments highlighting their personal remarks and understanding; (2) *the evaluation annotation*, where members can evaluate the knowledge resources according a scale (1-5), from a very good one to a very bad one. Moreover, members can give their personal feedback regarding the use of any knowledge resource; and (3) *the results annotation*, shows the lessons learnt from this use (i.e. positive and negative lessons learnt).

For the analysis annotation for example, we propose the following annotation properties (see figure 4):

- Author: is the member who writes the annotation.
- Date-Time: corresponds to the date of creation (or update) of the annotation.
- Annotation-body: is the element concerned by the annotation (a Knowledge resource, a part of a knowledge resource or an annotation).
- Sharing: the author may share or not his annotation.
- Annotation-type: which may be a "Question", asking for additional information; a "Comment", adding some remarks; an "Explanation", adding further clarification; an "Example", illustrating the annotation body,

Each annotation is associated to one or more concepts of an ontology. This allows mapping of the annotations to the elements of the ontology.

OWL-DL language may be used to implement our ontology, as it offers the consistency checking of our model and the querying which provides an improved exploitation and knowledge retrieval from complex knowledge bases. Thus, members can formulate complex queries such as: 'retrieve knowledge resources of a given topic and having high levels of score'.

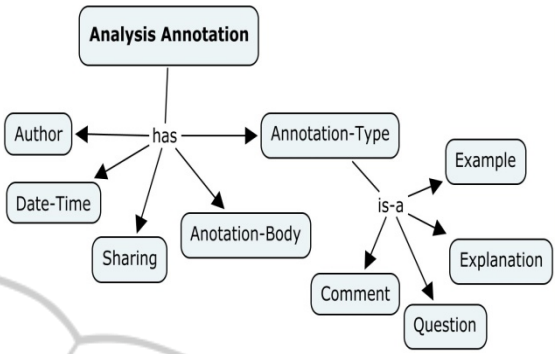

Figure 4: Analysis annotation model.

5.4 LO Model in the Context of a CoPE

The adoption of the standard LOM (2002), promotes exchange of LOs among different LMS, and offers higher potentials for finding existing learning content. However, decisions about reuse involve a broad set of issues about content, context and pedagogy that cannot be fully expressed in the LOM's metadata fields. The authors in (Jovanović et al., 2007) developed an ontology-based framework aimed at explicit representation of context-specific metadata. The core part of the proposed framework is a LO context ontology, that leverages a range of other types of ontologies (e.g., user modeling ontology and content structuring ontology to capture the information about specific context of use of a LO inside a learning design). Information of this kind can be rather useful for personalization of learning process in the LMS.

In the context of a CoPE, members need not only to find and reuse LOs in their courses, but moreover, to find the comments and feedback about LOs expressed by members having used them; the results of tests and experimentations in the LMS; information about how to use the LO (i.e. the context of use and contexts of possible reuse, etc.).
In our solution, we propose to adopt the standard LOM (2002) and the existing ontologies to annotate the LO. Moreover, we add a concept, called "LO-Reuse", to capture all the above mentioned elements: members' comments, their feedback, results, and so on.

Figure 5 shows the description of a LO's related metadata. The proposed metadata concerns: *the LO information context*, gives general information about the origin of the LO (developed in the CoPE or imported from any other source), its subject and

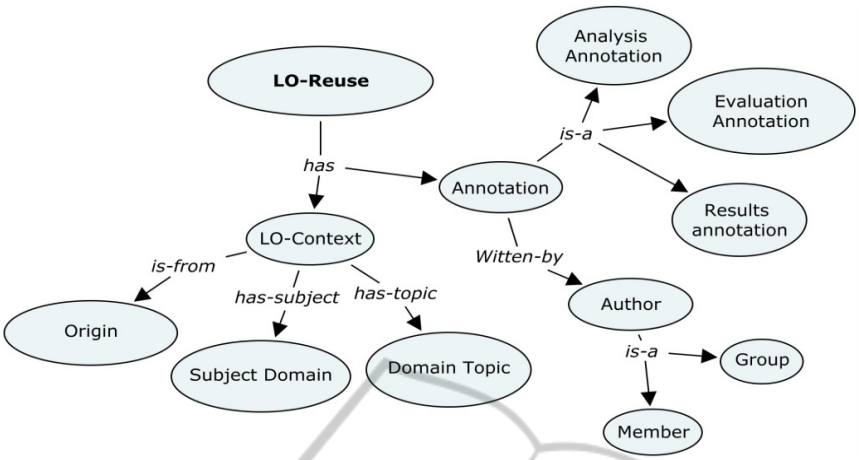

Figure 5: LO-Reuse metadata in the context of a CoPE.

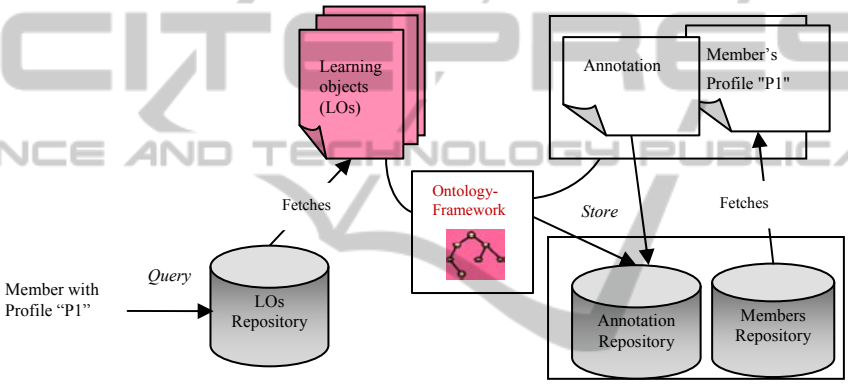

Figure 6: Example of knowledge capitalization for reuse.

topic domain; and *a set of annotations*, analysis, evaluation and results, provided by a member or group of members who have used the LO.

Using this concept, allows us to recommend the adequate LOs for members according to their profiles and needs. Moreover, when a member is seeking about LOs related to any subject and /or topic domain, it is possible to recommend him automatically LOs jugged as interesting (i.e. evaluated with a high level score) by other members having the same profile. The recommendation of the relevant LOs will help members in their activities and will improve their learning using the experience and feedback of other members, through the different annotations.

6 EXAMPLE OF USE

We consider a use case within Learn-Nett (Learning Network for Teachers and Trainers), a CoPE focused on a shared course and aims at preparing future teachers or trainers for educative uses of Information and Communication Technologies. The ontology-framework proposed will be useful for annotating the CoPE's knowledge resources such as LOs (e.g. a pedagogical and/or technical guide for the course). We suppose one teacher member (M1) of Learn-Nett having the profile (P1) wants to prepare a course concerning Software Engineering. As shown in figure 6, the teacher M1 can retrieve LOs from the memory. The "knowledge resources search service" uses the ontology framework to seek about the relevant resources that meets the needs of M1. One or more LOs can be found and displayed for the member, who will have the possibility to consult and/or download them. However, once using those resources, the member will have the possibility to annotate any of them using the "knowledge resource annotation service" (AnnotatKR).

In the following, we'll show through a series of screenshots how members interact with AnnotatKR to annotate a LO.

After using the LO in this course, the member M1 can write some comments highlighting his personal experience and analysis about it. He can also give some comments that will serve to improve it, ask a question, or give an example from his practice, using the "Analysis annotation module" (see figure 7).

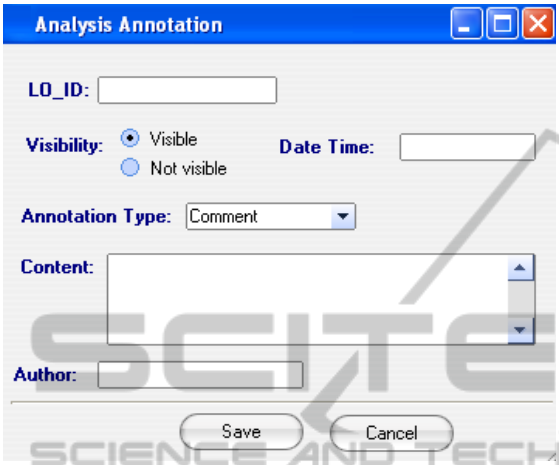

Figure 7: Analysis annotation module.

Moreover, the member M1 can participate to the evaluation of the LO by giving his own feedback and score using the "Evaluation annotation module", as shown in the figure 8.

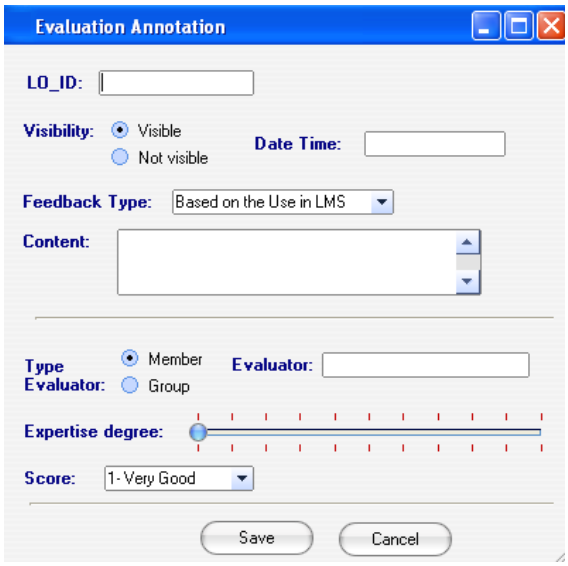

Figure 8: Evaluation annotation module.

Finally, the member M1 can use the "Results annotation module" to note positive and/or negative aspects from reflective analysis of the supervision methods throughout his effective experience of tutoring students (see figure 9).

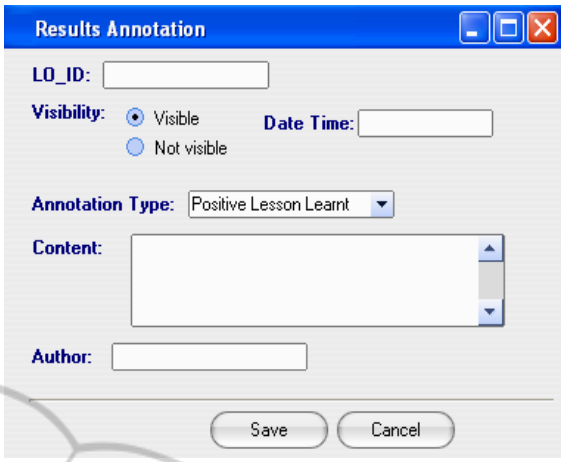

Figure 9: Results annotation module.

Once the LO's reuse-related metadata are fulfilled, the anchoring information and the information on the teacher are stored in the annotation repository.

Another teacher member (M2) can retrieve the same LO, and then he will have the possibility to reuse, not only the LO content but also the comments found on it. Moreover, he will have an idea about the degree of interest of the LO according to the given scores. He will have access to the results deduced from its use by other members. Finally, he can also create annotations on that resource.

7 DISCUSSION

The work presented in this paper aims to capitalize the tacit knowledge owned by members of a CoPE, using semantic annotations. We focused in this paper on LOs just in order to illustrate the process of capitalizing knowledge using annotations. However, this approach can be used to annotate all the knowledge resources, artefacts and processes in the CoPE. For instance, we can annotate the proposed solutions during the problem-solving process.

Our main objective is to facilitate the capitalization of tacit knowledge (know-how, experience, feedback, etc.) of members when using knowledge resources so as to facilitate the knowledge access and reuse. We can summarise the main results expected by this approach as follows:

- Members can share and reuse their tacit knowledge through the analysis annotation.
- They can have an idea about the different feedback and evaluations of other members who have used the knowledge resources.
- The knowledge resource search service can use the scores of a knowledge resource from

the different evaluation annotations and then recommend those having a high level of scores to other members.

- The service can refine the search process by finding the resources that meet the needs of members and for what members having the same profile used them and evaluated them with a high level of scores.
- The manager of the CoPE can have an idea about the utilisation of knowledge resources by members and about the participation of members too in the annotation process.
- Members can learn from the experience of others through the results annotations. This will help them to improve their expertise and practical knowledge.

Furthermore, in addition to this different forms of knowledge acquisition and reuse, this initiative, will help members to improve their engagement in the CoPE. Indeed, this will motivate them to collaborate and participate actively in the community. The collaboration here concerns especially the reification process of tacit knowledge in the community memory. In addition, we can consider the annotations as a trigger for other activities in the community, as they can open further discussions and exchanges among members.

8 CONCLUSIONS

The present paper described an ontology based-framework for knowledge capitalization and reuse within online CoPEs. The ontology allows to annotate knowledge resources in order to facilitate their retrieval and reuse by CoPEs' members. Our main objective is to organize the process of capitalization of knowledge and to allow a knowledge elicitation through manual and automatic annotation of knowledge resources by capturing the members' experience and feedback. We have proposed a model for manual annotation.

In our future work, we envisage to complete our ontology, integrate a SPARQL engine to allow querying of the knowledge base, and to allow an automatic and semi-automatic annotation of knowledge resources.

Finally, it is necessary to check the usefulness of the framework and to describe the experience in the members' feedback and point of view. To do so, we'll evaluate our approach in a CoPE to be created in the University of Science and Technology (USTHB) called A-CoPE (Algerian CoP of E-learning), and whose main objective is to promote e-learning in higher education context.

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